Trochus niloticus (Linnae 1767) growth in Wallis Island

Soazig Lemouellic[1] and Claude Chauvet[1,2]

Abstract

A study of the Wallis Island *Trochus niloticus* stock was undertaken between 2004 and 2006. The growth of individuals was studied by tagging. Results are presented and compared with growth trends in other regions of the Pacific.

Introduction

Trochus niloticus (Linnae 1767) is a marine gastropod. It belongs to the Prosobranchia subclass, Archaeogastropoda order and Trochidae family (Hickman and McLean 1990). Wild populations of *T. niloticus* occur between longitudes 90° W (Andaman Islands, India) and 180° W, and latitudes 20° N and 25° S. The Wallis *T. niloticus* population is therefore on the edge of the species' area of natural occurrence (Fig. 1). During the last century, some populations were artificially transplanted to the east, north and southeast of the species' occurrence zone in the wild (Gillett 2002). Although there were some failures, as in the Loyalty Islands with New Caledonian juveniles, most of these populations settled successfully (Hoffschir et al. 1989; Chauvet et al. 1998).

T. niloticus inhabits the intertidal and shallow subtidal zones. Its preferred habitat is the moderately exposed coral reef shore (McGowan 1956; Gail 1957; Smith 1979). Its diet is herbivorous, and it forages on small green and red seaweeds (Cyanophycae and Phaeophycae), benthic diatoms and Foraminifera (Asano 1944). *Trochus* spp. are gonochoric, without any external sexual dimorphism. Females and juveniles, however, have green gonads, whereas males have white gonads (Amirthalingam 1932a, b). Spring tides mark the breeding period, with external fertilisation and nocturnal spawning. Female spawning is induced by the presence of sperm (Amirthalingam 1932c; Nash 1985). In Micronesia, Australia and the Andaman Islands, spawning occurs all year round (Rao 1936). In New Caledonia, *T. niloticus* spawns between October and

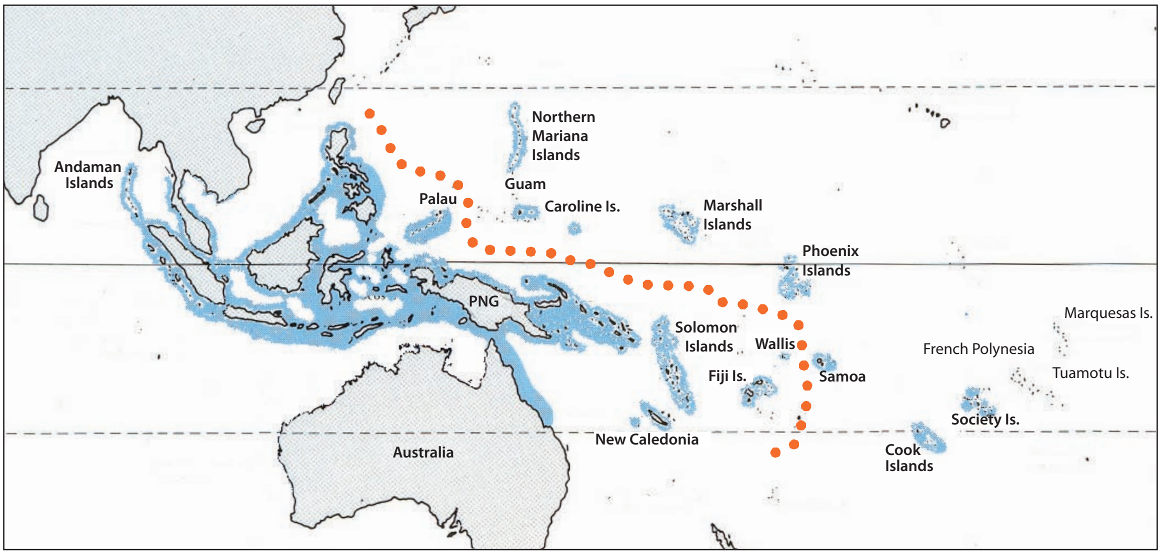


Figure 1. Distribution of *Trochus niloticus.* Natural stocks occur west of the dotted line. To the east, implanted populations of the Northern Mariana, Guam, Yap, Chuuk, Marshall and Phoenix Islands originated in Palau; the Society Islands population was implanted from Vanuatu and New Caledonia, whereas the Cook Islands population came from Fiji Islands.

1. University of New Caledonia, BP R4, Noumea, New Caledonia.
2. Email: chauvet@univ-nc.nc; ph: +687 265 828, fax: +687 273 272.

April (Bour 1989). Heslinga and Hillmann (1981) and Nash (1985) described the species' reproductive behaviour and larval development in Australia (Great Barrier Reef) and Palau, respectively. Fertilised eggs are covered by a thick chorion. The first division occurs between 30 and 60 minutes after fertilisation and the trochophore larva hatches after 12 hours. At the end of the first day, the larva becomes a veliger. Although the larva is teleplanic, its metamorphosis into a juvenile occurs classically during the third day of its life (Heslinga and Hillmann 1981; Nash 1985). Metamorphosis and settlement are stimulated by the presence of red algae or humic acids (Heslinga and Hillmann 1981).

The shells of *T. niloticus* are used as raw materials by the nacre button industry. The value of this natural material has increased steadily since the emergence of plastic materials. Artisanal jewellers put the shells to a variety of uses and designs, such as inlaying and incrustation. Commercial demand for these products has been on the rise for more than 30 years. It is therefore necessary to manage stocks carefully, particularly on small islands. Knowledge of growth rates is the basis of good management. Mean individual growths were studied in different islands of the Pacific Ocean and fitted to the Von Bertalanffy model, which has proven robust. Although similar, growth rates in different locations, such as Japan (Honma 1988), New Caledonia (Bour et al. 1982), the Great Barrier Reef in Australia (Nash 1985) and Vanuatu (Bour and Grandperrin 1985), differ sufficiently to suggest that they are specific to geographical units. In that case, management advice and practices should be adapted to each stock. The present study, designed as a follow-up to a short study of *T. niloticus* growth (Chauvet et al. 2004), aims to document the spring growth rates of tagged individuals.

Material and methods

T. niloticus inhabits the outer slope between the reef crest and 15 m depth (Chauvet et al. 2004). Individuals were therefore captured by snorkelling. Between 80 and 150 individuals were caught daily, totalling 477 individuals in a week. For the growth survey we developed a tagging method that enabled the easy spotting of marked individuals from the surface. Recaptures were done by scientists as well as by fishers. On recapture, the number of individuals and their size were recorded. All individuals were released at the site of capture. On the first capture, the shells were taken out and kept in an immersion net until tagging.

Tagging process

Trochus were tagged aboard the boat in batches of 10 individuals. Each individual was laid on its side horizontally on an openwork surface, facilitating the different steps of the tagging:

1. the shell is scratched clean with a knife on a 5 x 2 cm surface;
2. this surface is then polished with a sandpapering machine;
3. the surface is air-dried with a diving bottle;
4. the surface is cleaned with acetone to improve the resin's sticking power;
5. the first thin coat of epoxy is applied; the resin must remain tacky for ca. 7 minutes and must then be hardened in 2 minutes;
6. the number (Dymo tag) is placed; and
7. a second coat of resin is applied to cover the tag.

The specimens are then placed in an immersion net until they are individually released at the place of their capture. The best colours for tags are orange and yellow because they are easily discernible in shallow water. As concretions will cover up the mark in 4–6 months, it is advisable to double the tagging with an internal shell inscription made with a pencil.

The tagged specimens are then returned one by one to their natural habitat. Care should be taken during this step to ensure survival of the specimens and success of the tagging experiment. To prevent them from being turned over by waves or current, the specimens are repositioned so that they can quickly re-attach themselves to the substrate. When a *T. niloticus* is upside down it becomes vulnerable to predation and can be eaten by small fish, such as Labridae. Whenever possible, each trochus is released in an environment that matches the fouling of its shell, the best option being to take it back to the site where it was caught.

Recapture

Recapture is done by scientists as well as fishers. A reward is provided for trochus returned, enough to encourage fishers to send them back, but not too high to prevent the shells from being actively sought out.

Measurements

Two diameters were recorded: D1 and D2. Both pass over the ombilic (Fig. 2). D1 starts at the hollow of the crown basis; it is the most robust measurement. D2 is the longest possible diameter (D2 > D1). Measuring D2 can require several successive trials and the result may be imprecise. However, it is the measurement that most fishers use as fishing regulations almost always refer to the longest diameter. The following formula (Fig. 2) can best describe the relationship between D1 and D2 (r = 0.99):

$$D2 = 1.1915\, D1 - 2.0606 \quad (n = 720)$$

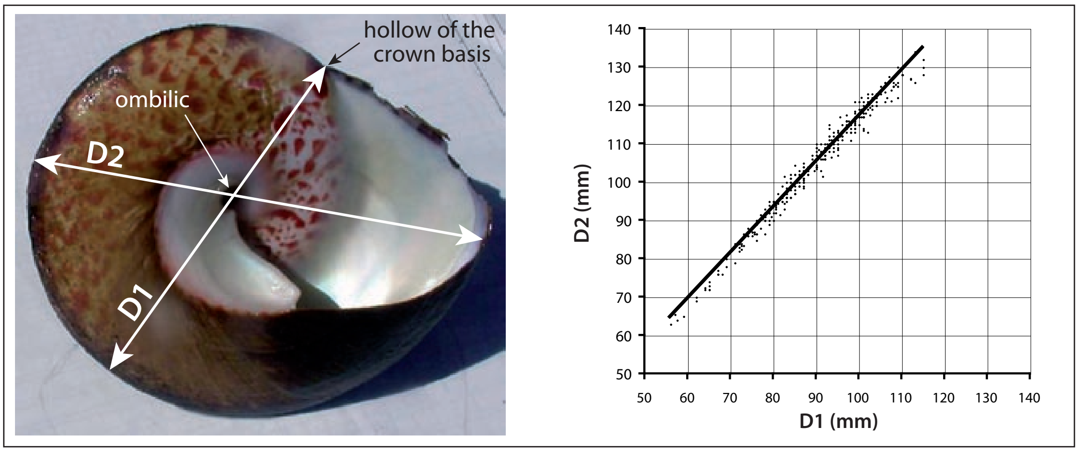


Figure 2. Regression of the two diameters (D1 and D2) of the basis of the shell.

Data treatment

Experimental results – shell size increments in relation to time at liberty – were used to calculate a Von Bertalanffy growth curve [$LF_t = LF_{inf}\ (1 - e^{-K(t-t0)})$] for all individuals measured. The length derived by the time (dLF/dt) is:

$$dLF/dt = LF_{inf.}\ K.e^{-K(t-t0)}$$

which, following the Von Bertalanffy curve, would give:

$$e^{-k(t-t0)} = 1 - LF_t/LF_{inf}$$

therefore:

$$dLF/dt = K\ (LF_{inf} - LF_t)$$

The Von Bertalanffy curve parameters are then obtained from this linear equation (where K is the slope, and KLF_{inf} is the y-intercept).

The confidence interval of r (Pearson product-moment correlation coefficient) is obtained by inverse tanh transformation (z-transformation in Dagnelie 1980):

$$z_1 = 1/2\ Log_e\ [(1+r)/(1-r)] - t_{a/2}\ /(n-3)^{0.5}$$
and
$$z_2 = 1/2\ Log_e\ [(1+r)/(1-r)] + t_{a/2}\ /(n-3)^{0.5}$$

Which gives:

$$r_1 = [\exp(2z_1) - 1]\ /\ [\exp(2z_1) + 1]$$
and
$$r_2 = [\exp(2z_2) - 1]\ /\ [\exp(2z_2) + 1]$$

Results

Trochus were recaptured over a period of one year, beginning in the first week after the onset of the tagging experiment. A total of 114 individuals were recaptured. The standard time unit was a day, and for LF_i the mean size increment of the shell during the time at liberty ($LF_i = [LF_{recapture} - LF_{capture}]\ /\ 2$). These data [$dLF/dt$; LF_t] provide the linear model that calculates K and $LF_{inf.}$ (Fig. 3). The confidence interval of r is – 0.744, which is between $r_1 = - 0.666$ and $r_2 = - 0.806$ for $P_{(1-a)} = 0.95$. The value of r is therefore significantly different from zero.

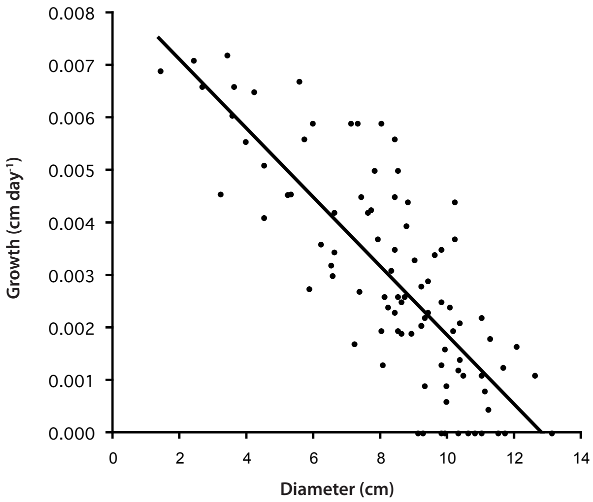


Figure 3. Tagged data fitted with:
$dLF/dt = K\ (LF_{inf} - LF_t)$.

The slope (K) is in day^{-1} (K = 0.994) and could be transformed in yr^{-1} to obtain the classical expression of the Von Bertalanffy parameters: $K = 0.358\ yr^{-1}$ and $L_{inf} = 12.23$ cm (Fig. 4).

Discussion

These values are similar to those obtained by Chauvet et al. (2004) using statistical methods: $K = 0.35\ yr^{-1}$ and $L_{inf.} = 12.5$ cm. The growth curve of *T. niloticus* indicates that young trochus of Wallis Island grow quickly when compared to those of Vanuatu or New Caledonia (Fig. 5 and Table 1), which could explain why their shells

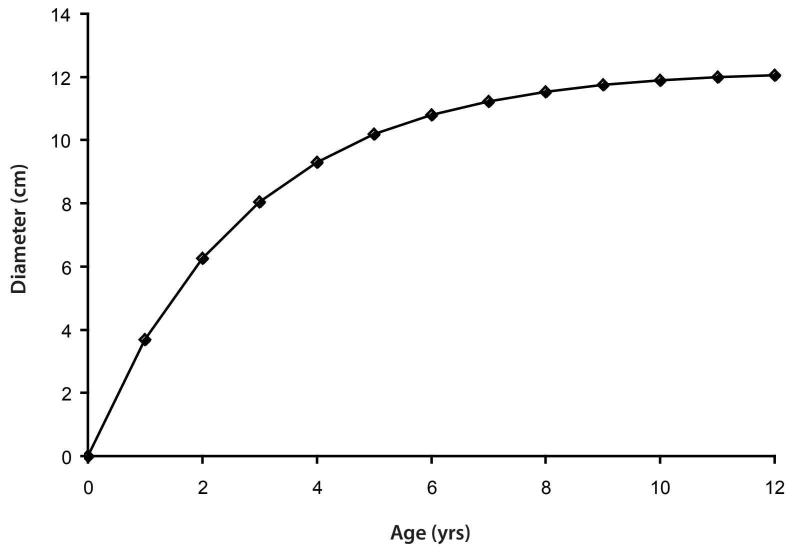
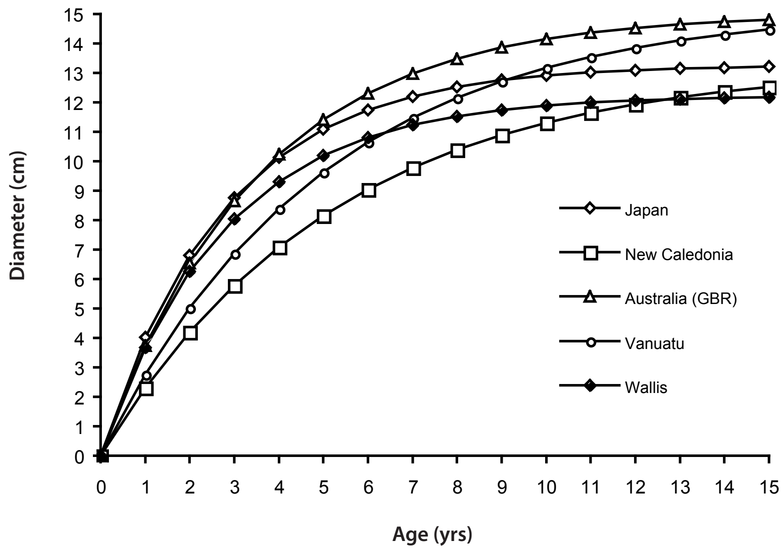


Figure 4. *T. niloticus* growth curve on Wallis Island.



Japan	(Honma 1988):	$L_t = 13.27 (1 - e^{(-0.36 t)})$
New Caledonia	(Bour et al. 1982; Bour 1989):	$L_t = 13.30 (1 - e^{(-0.19 t)})$
Australia (GBR)	(Nash 1985):	$L_t = 15.01 (1 - e^{(-0.28 t)})$
Vanuatu	(Bour et Grandperrin 1985):	$L_t = 15.23 (1 - e^{(-0.20 t)})$
Wallis	(present)	$L_t = 12.23 (1 - e^{(-0.358 t)})$

Figure 5. *T. niloticus* growth curves in different parts of the Pacific Ocean (Von Bertalanffy curves).

are thinner than trochus in other Pacific islands. Possibly correlated with weak shells, the maximum size observed was small, with few individuals reaching a diameter length of 13.5 cm. Gimin and Lee (1997) showed a correlation between growth, mortality and substrata. Sexual maturity was established at 6 cm (Chauvet et al. 2004); therefore, according to this growth curve (Fig. 5), trochus in Wallis become adults at two years of age.

Table 1. Estimated shell diameter of *T. niloticus* with age in different locations.

Age (years)	Shell diameter (cm)				
	Japan	New Caledonia	Australia (GBR)	Vanuatu	Wallis
0	0.00	0.00	0.00	0.00	0.00
1	4.00	2.30	3.63	2.76	4.40
2	6.80	4.20	6.38	5.02	7.36
3	8.76	5.78	8.47	6.87	9.34
4	10.12	7.08	10.05	8.39	10.66
5	11.07	8.16	11.25	9.63	11.55
6	11.74	9.05	12.16	10.64	12.15
7	12.20	9.78	12.85	11.47	12.55
8	12.53	10.39	13.38	12.16	12.81
9	12.75	10.89	13.78	12.71	
10	12.91	11.31	14.08	13.17	
11	13.02	11.65	14.30	13.54	
12	13.10	11.94	14.48	13.85	
13	13.15	12.18	14.61	14.10	
14	13.19	12.37	14.71	14.30	

The growth rate of the Wallis *T. niloticus* (K = 0.358 yr^{-1}) is most similar to that recorded by Honma (1988) in Japan. Records from other regions in the Pacific Ocean – New Caledonia (Bour 1989), Australia (Nash 1985) and Vanuatu (Bour and Grandperrin 1985) – indicate a slower growth than what we obtained in Wallis. The asymptotic size recorded in Wallis (12.23 cm) was, however, the smallest reported in the literature. Wallis trochus reach nine-tenths of their maximal size at 6.5 years of age. Taking into account that less than 1 per cent of them reach sizes beyond 12.5 cm, we assume that 6.5 years is the life expectancy of trochus in Wallis Island.

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